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Fuel reduction and restoration of pine/hardwood ecosystems severely impacted by the recent southern pine beetle (Dendroctonus frontalis) epidemic in the southern Appalachians

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Project title: Fuel reduction and restoration of pine/hardwood ecosystems severely impacted by the recent southern pine beetle (*Dendroctonus frontalis*) epidemic in the southern Appalachians

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Project Location: Cherokee National Forest, Ocoee, Tennessee

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This final report details findings to date and proposed and accomplished deliverables. Details on the study background, objectives, methods, and evidence to support these findings are presented on our updated web page (http:// www.srs.fs.usda.gov/coweeta/), which can be considered a contribution to the final report.

SUMMARY OF FINDINGS TO DATE

As a result of this most recent SPB epidemic (1999-2003), thousands of hectares of dead pine trees have created wildfire-hazard conditions in the southern Appalachians. One of the challenges for land managers is how to return fire to these ecosystems after (1) nearly a decade of exclusion, and (2) the more recent SPB mortality enhanced fuel loads. Higher fuel loads have the potential to increase fire intensity and severity. At the extremes, fires of high intensity and severity can have a large effect on ecosystem structure and function. The objectives of our research were: (1) to quantify fuel load reduction methods (pine overstory felling, material left on site followed by prescribed fire; prescribed fire only; and no treatment) in pine/hardwood forests heavily impacted by southern pine beetle induced tree mortality, and (2) to evaluate the effects of further restoration treatments including planting shortleaf (*Pinus echinata*) pine and seeding native bluestem grasses on ecosystem structure and function in these pine-hardwood forests. Eight sites on the Cherokee National Forest, eastern Tennessee were chosen to evaluate restoration of shortleaf pine ecosystems. Four sites were cut+burn (2 dry, 2 sub-mesic), two sites were burn only, and two sites were used as references. All eight sites had substantial pine mortality before the initiation of fuel treatments (Figure 1). Sites were cut in summer 2005 and burned in March 2006. All site measurements for vegetation composition and diversity, carbon and nitrogen pools, soil and soil water chemistry, and success of planted pine and bluestem grasses for the pre-treatment (2005) and two years post-treatment (2006, 2007) have been completed. We have provided demonstrations and tours to user groups, oral and poster presentations at scientific meetings, and three published manuscripts (2 proceedings and 1 peer reviewed). In addition, three peer-reviewed manuscripts, one MS thesis, and one proceedings paper are in progress (see Deliverables table below).

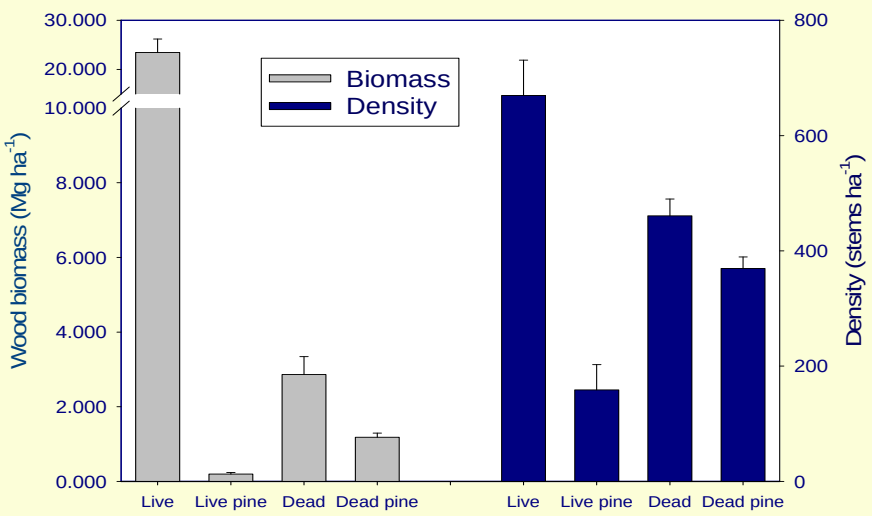

Figure 1. Pre-treatment (2005) aboveground biomass of live and dead trees (branch + bole). Biomass was estimated from species specific allometric equations.

Site preparation burns were implemented on six sites in March 2006. Ignition was a hand-lit backing fire along ridges, and then a head fire was hand-lit from the lower slopes. This prescription resulted in high intensity and short duration fires (Figure 2), which produced moderate severity burns.

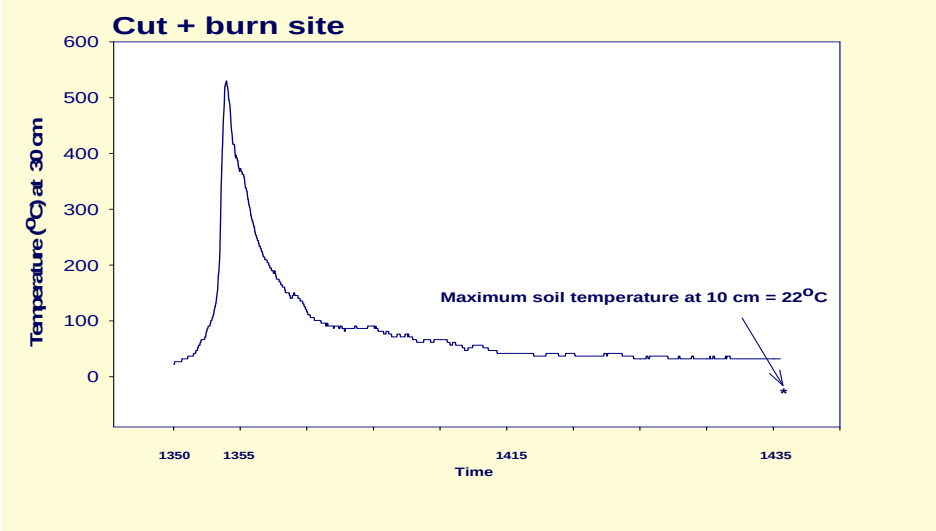

Figure 2. High intensity, short duration fire on a cut+burn site, Ocoee, TN.

We measured vegetation; soil and soil solution chemistry; forest floor mass, carbon and nitrogen; and fuel load before (2005) and for two years after (2006, 2007) the burn treatments.

Results

Consumption of large wood (1000 hr fuels) was greatest on the dry, cut+burn treatment. The fires consumed nearly all fine fuels (litter and small wood [1-100 hr]) and 23-31% of the larger fuels (1000 hr). Nearly all the litter layer was consumed, but a large proportion of the humus layer remained intact (Figure 3).

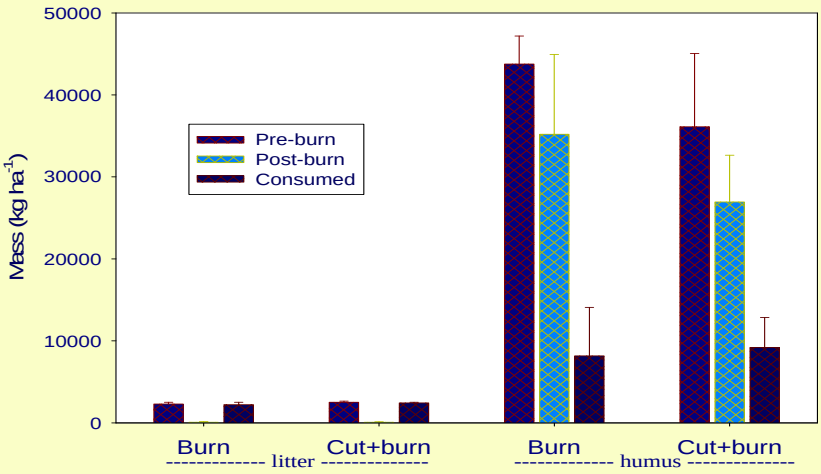

Figure 3. Forest floor litter (Oi) and humus (Oe+Oa) mass pre- and post-burn.

We found significantly higher understory density (all woody species and tree species only) on the burn only and sub-mesic, cut+burn treatments (Figure 4).

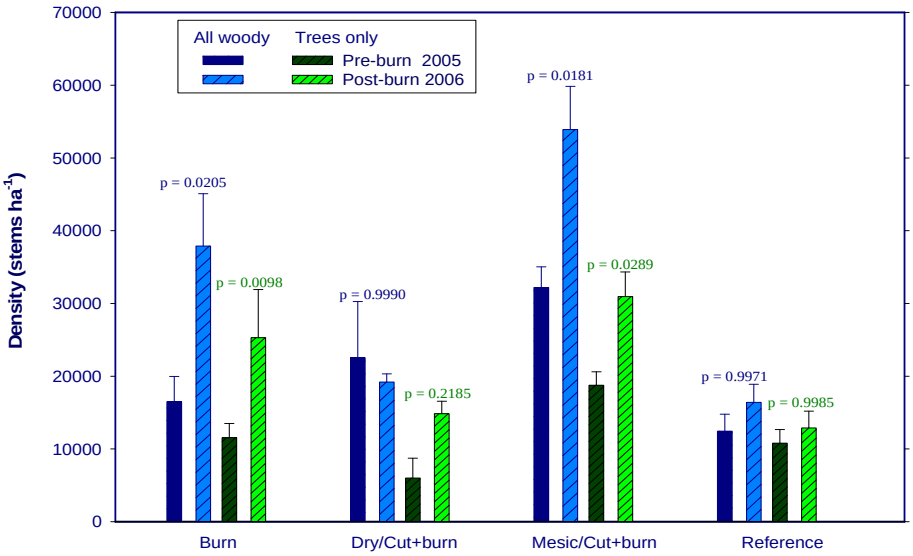

Figure 4. Density of understory woody species before and after the prescribed fires at Ocoee, TN. Significant differences evaluated by repeated measures anaysis of variance (Proc Mixed, SAS 2002).

For the herbaceous layer, percent cover and species richness significantly increased on all treated sites by the second year after burning (Figure 5); whereas no significant changes were detected on the reference sites.

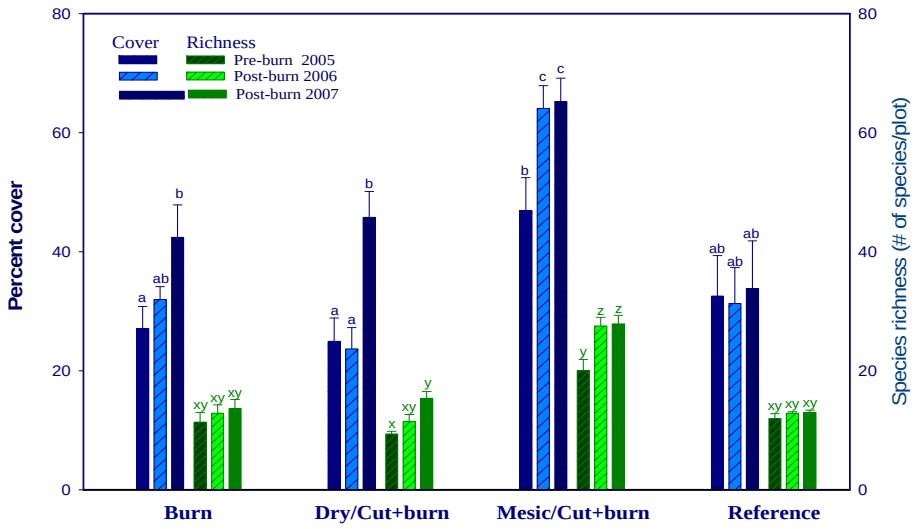

Fig. 5. Percent cover and species richness of herbaceous layer species before (2005) and the first (2006) and second (2007) growing seasons after the prescribed fires.
Significant differences were evaluated by repeated measures analysis of variance (Proc Mixed, SAS 2002).

Summary

- Before the prescribed fires, all sites had a large amount of dead wood (Figure 1) due to pine mortality from the southern pine beetle.
- In the burn only treatment, the fire burned standing dead trees, which contributed large wood mass to the forest floor; more new wood was contributed than consumed to down material. The cut+burn treatment reduced down wood mass.
- On these high intensity burns, even though the forest floor litter layer was consumed, a large proportion of the humus layer remained intact (Figure 3).
- Understory wood density was high before the treatments due to increased number of sapling following the pine mortality. Density significantly increased on the burn only and sub-mesic, cut+burn treatments the first growing season after the burn (Figure 4).
- Percent cover and species richness of the herbaceous layer significantly increased on all treated sites by the second year after burning. The only significant changes the first year after burning were on the sub-mesic, cut+burn treatment (Figure 5).
- We are preparing three additional manuscripts (see list below) on this project to evaluate changes in vegetation composition and diversity, carbon and nitrogen pools, soil and soil water chemistry, and success of planted pine and bluestem grasses.

DELIVERABLES **Proposed**	**Accomplished**	**Status**
Annual progress reports	Annual progress reports completed	Done
Workshop/Conference	Prescribed fire workshop for resource managers o Workshop tentatively planned for May 2009	Planned for May 2009
Demonstration Tours Onsite tours of the treatment areas to resource managers, user groups, and others	Tours have been provided to various user groups, and the Chief of the Forest Service: o University of Tennessee, Prescribed fire class, March 28, 2006. Shortleaf pine fire restoration treatments, Ocoee, TN. Presented by Katherine J. Elliott o Deputy Forest Supervisor, Timber and Fire Management Officers, Public Relations Officer, Forest Botanist, Ocoee District Ranger from the Cherokee National Forest and representatives from the Southern Appalachian Biodiversity Project, March 30, 2006. Fire prescriptions to restore shortleaf pine ecosystems in the southern Appalachians. Presented by Elliott. o University of Georgia, Silvicultural undergraduate class, April 17, 2006. Use of fire to restore pine/hardwood ecosystems in the southern Appalachians. Presented by Elliott. o Berry College, Rome, GA, April 17, 2007. Using fire to restore shortleaf pine/bluestem grass ecosystems in the southern Appalachians. Presented by Elliott o USFS Chief Abigail Kimball and delegates, May 8, 2007. Prescribed fire in southern Appalachians and how to restore shortleaf/pine ecosystems using fire. Presented by Elliott o USDA Forest Service, International programs, Chinese State Forestry Administration; Cherokee Forest Supervisor & staff; University of Tennessee; Memphis Zoo; International Programs, WO, Ocoee, TN, Aug 12, 2007. Prescribed fire to restore shortleaf pine/bluestem grass ecosystems. Presented by Elliott	Done
Presentations Posters and oral presentations will be submitted to professional meetings	Posters and oral presentations were produced for several regional and national meetings: o Elliott, Katherine J. and James M. Vose. 2006. Watershed responses to fire. Rx310 Introduction to fire effects training for professionals. Sponsored by USFS, NPS, US Fish & Wildlife, BIA, BLM, and the Nature Conservancy, Pigeon Forge, TN. January 31, 2006. Presented by Elliott. o Elliott, Katherine J. and James M. Vose. 2006. Effects of Fire on Watersheds. 2nd Interagency Conference on Reseach in the Watersheds. Hosted by USDA Forest Service, Southern Research Station, Coweeta	Done

	Hydrologic Laboratory, Otto, NC, May 15-17, 2006. Presented by Elliott. o Elliott, Katherine J., James M. Vose, Jennifer D. Knoepp, and Barton D. Clinton. 2007. Restoration of Degraded Ecosystems. (Abstract p. 71) Southern Research Station, Forest Service USDA, All-Scientist Meeting. January 29-31, 2007. Lake Lanier, GA. Presented by Elliott. o Elliott, Katherine J., James M. Vose, Jennifer D. Knoepp, and Barton D. Clinton. 2007. Using fire to restore pine/hardwood ecosystems severely impacted by southern pine beetle (*Dendroctonus frontalis*) in the southern Appalachians. p. 93 (published abstract). 2nd Fire Behavior and Fuels Conference, The Fire Environment – Innovations, Management, and Policy, Destin, FL, March 26-30, 2007. Presented by Elliott. o Elliott, Katherine J., James M. Vose, Jennifer D. Knoepp, and Barton D. Clinton. 2007. Fire in the southern Appalachians: restoration of pine/hardwood ecosystems. p. 36 (published abstract). Southern Appalachian Man and the Biosphere 18th annual conference: Rising to the challenges of a new century. Johnson City, TN, October 22-24, 2007. Presented by Elliott. o Newman, Amanda C., Ronald L. Hendrick, and Katherine J. Elliott. 2007. Shortleaf Pine and Bluestem Community Restoration in the Southern Appalachians. (published abstract, J. Forestry 105: 428). Society of American Foresters, Portland, OR, November, 2007. Presented by Newman. o Elliott, Katherine J., James M. Vose, and Alan S. White. 2008. Pine regeneration following wildland fire. Fort Valley Experimental Forest – A Century of Research, 1908-2008. Flagstaff, AZ, August 7-9, 2008. Presented by Elliott.	
Manuscripts to peer review journals	Publications examining fire-effects have been produced in several formats, including peer review and proceedings.	Done
	o Elliott, Katherine J. and James M. Vose. 2006. Effects of prescribed fire on southern Appalachian ecosystems. 3rd International Fire Ecology & Management Congress, special symposium titled: "Appalachian Fire Regimes", San Diego, CA, November 13-17, 2006. 6 pp. o Elliott, Katherine J. and James M. Vose. 2006. Fire effects on water quality: A synthesis of response regulating factors among contrasting ecosystems. Pp 77-87, In D.L. Fowler (compl.), Proceedings of the 2nd Interagency Conference on Research in the Watersheds, May 15-17, 2006, Coweeta Hydrologic Laboratory, Otto, NC.	

	o Love, Jason P., James M. Vose, and Katherine J. Elliott. 2007. Effects of restoration burns on macroinvertebrates and salamanders in southern Appalachian pine-oak forests. Journal of the North Carolina Academy of Science 123 (1):22-34.	
Manuscripts to peer review journals	Planned future journal articles comparing pre- and post-fire conditions: o Elliott, Katherine J., James M. Vose, and Alan S. White. **In review-2008**. Pine regeneration following wildland fire. 8 pp. *In* Proceedings Fort Valley Experimental Forest – A Century of Research, 1908-2008. Flagstaff, AZ, August 7-9, 2008. USDA Forest Service, Rocky Mountain Research Station, Fort Collins, CO. o Elliott, K.J., J.M. Vose, and B.D. Clinton. Restoration of degraded shortleaf pine/mixed hardwood ecosystems: fire effects on flora and biodiversity. Will be submitted to *Fire Ecology*. o Amanda C. Newman. **Dec 2008**. Success of planted shortleaf pine and bluestem grass on prescribed burn sites. Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA. MS Thesis. o Elliott, K.J., and B.D. Clinton. Fuel reduction following site preparation burning in shortleaf pine forests. Will be submitted to *International Journal of Wildland Fire* o Knoepp, J.D., K.J. Elliott, and J.M. Vose. Fire Effects on Nutrient Cycling and Water Quality. Will be submitted to *Forest Ecology and Management.*	In progress